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VARIATION AND CORRELATION IN THE FLOWERS OF LAGERSTROEMIA INDICA.

BY J. ARTHUR HARRIS.

Lagerstroemia indica, frequently grown as an ornamental shrub in the United States under the common name of Crape Myrtle, is a member of a genus of about thirty species*, belonging to the Lythraceae, a family of considerable interest to floral ecologists through the researches of Darwin. For the most part the genus is confined to the oriental and austral Asian region, and this species seems to be the only one extensively cultivated for ornamental purposes.

Briefly, the structure of the flower is as follows: The petals are unguiculate, with an oval to orbicular crispate limb. The numerous stamens have filiform filaments and elliptical anthers with broadly pulviniform connectives. The greater number of the stamens are bright yellow in color, but one in front of each sepal is usually larger, both as to filament and anther, and of a reddish instead of a yellow color. In young buds the anthers are not distinguishable by their color, both kinds being a light yellow. The characteristic colors are developed as the buds grow older.

Biological observations on the flowers are very few. Darwin, in his classic paper on *Lythrum*†, was the first to notice the species in this respect. He found it strongly variable in the number of stamens, and suggested as a cause its growth in the hothouse. He usually found five long stamens with thick flesh-colored filaments bearing anthers producing green pollen, and from 19 to 29 small stamens with yellow filaments and anthers producing yellow pollen. In other cases, however, he found those with only one to four larger stamens with anthers producing green pollen, which in some cases was replaced by that which was yellow in color; one anther, indeed, offering the peculiar case of one locule containing bright yellow

* Koehne, E. Lythraceae. Das Pflanzenreich. 19. 1903.

† Darwin, C. Jour. Linn. Soc., Bot. 8: 176. 1865.

and the other bright green pollen*. He also suggests here and in his "Different Forms of Flowers," that *L. indica* may be a heterostyled form†. Fritz Müller‡ fertilized a *Lagerstroemia*, infertile to its own pollen, with yellow and green pollen from another variety or species in other gardens. Both kinds produced apparently good seed, though only some of those from the green pollen germinated. In his paper on dimorphism in the anthers of pollen flowers, Hermann Müller§ assigned the same interpretations to the structure of *Lagerstroemia* as to other forms in which there is a color dimorphism in the anthers, namely, that the central yellow anthers serve as organs of attraction and furnish booty to the visitor while the blue or green anthers, which are not observed by the visitors because of their resemblance in color to the background formed by the petals, furnish pollen for fertilization. Koehne¶ suggests that in respect to this character the genus *Lagerstroemia* is still in the process of evolution, since the forms may be arranged in a complete series from those in which there is no differentiation in the androecium to those in which the dimorphism of the stamens is most highly developed. The reference to green stamens by some writers is apparently a slip of the pen. Knuth in his Handbook reviews Müller's work. Koehne in his recent monograph suggests the possibility that the forms in which the stamens are not dimorphic have been reduced from those in which the dimorphic condition prevails, but he inclines much more to the opinion that the dimorphism is in a state of evolution, supporting this

* I have seen several stamens intermediate in size between the typical large and small. Darwin noticed one petal with a furrow near the base of the limb containing pollen. In several flowers I found one or all of the large stamens with the anthers more or less completely metamorphosed into the orbicular crispate limb, while the filament represented the claw of the typical unguiculate petal. I mention these cases because of the similarity of the filament of the large stamens to the claw of the petal.

† Koehne states that all species are homostylous. The styles of all the flowers I have seen are of sensibly the same length.

‡ Müller, F. Nature. 27: 364. 1883.

§ Müller, H. Kosmos. 13: 254. 1883.

¶ Koehne, E. Engler's Bot. Jahrb. 6: 45. 1885.

view by the statement that the species in which the occurrence of only one kind of stamens is most typical, *L. speciosa*, is by far the most widely distributed and may represent the oldest species of the genus.

Since this species has attracted so much attention, it seems worth while to place on record the observations which I have made on the variability of the flowers of a lot of plants growing at the Missouri Botanical Garden. In putting these observations into print, I wish to make very clear the fact that I do not submit the constants secured here as typical of the entire species. They are based on several hundred flowers from about a dozen individuals. The probable errors of the constants calculated in this paper are low, but these show merely the degree of reliability of the constants for the series of material in hand, and must not be interpreted as fixing the limits of trustworthiness of constants for the species as a whole. At St. Louis the shrubs must be taken into the house during the winter. To gain a satisfactory knowledge of the variability of the flowers the data should be collected in the South, where the plant is hardy out of doors; or better still, in its native habitat. Of course the ideal thing would be to have comparative biometric studies of several species of *Lagerstroemia* growing in their own habitats, where their ecological relationships might be satisfactorily investigated. The hope of interesting some one who has opportunity to carry out this work as it should be done, is the chief object of this paper. My observations merely emphasize again the importance of what others have written, and contribute a little to the quantitative data of the subject, leaving the working out of satisfactory constants to represent the species as a whole to some one who has more adequate materials.

In 1903, 1904 and 1907 I was able to secure countings of sepals, petals and large stamens from the shrubs in the Missouri Botanical Garden. It was not possible to count the small stamens, as well, because of lack of time. The material was collected primarily for some physiological work which required the stamens to be removed and used quickly. Even had time been available their number is so large that it

would have involved a considerable amount of labor. The plants which furnished the material were of varying ages. It is not safe to refer any differences observed in the constants from year to year to any conditions under which the plants flowered, for the proportion of the flowers which each individual contributed may vary from year to year. The data are given in the form of correlation tables showing the relationship between sepals and petals, sepals and stamens, and petals and stamens in Tables I to VIII.

Considering first the variabilities, we note that the distributions are very irregular, falling wide of the symmetrical Gaussian distributions which some biologists of great reputation still hold to represent the variability of all organisms. But it will hardly be profitable to discuss skewness or other statistical characteristics of these distributions. For such work larger series grown under less abnormal conditions should be used.

TABLE A. VARIATION CONSTANTS FOR LAGERSTROEMIA.

Series	Average and Probable Error.	Standard Deviation and Probable Error.	Coefficient of Variation.
Sepals, 1903.	5.879 $\pm$.029	.433 $\pm$.021	7.362
Sepals, 1904.	5.969 $\pm$.008	.338 $\pm$.006	5.764
Sepals, 1907.	5.758 $\pm$.011	.441 $\pm$.008	7.657
Petals, 1903.	5.879 $\pm$.029	.433 $\pm$.021	7.362
Petals, 1904.	6.024 $\pm$.006	.260 $\pm$.005	4.316
Petals, 1907.	5.718 $\pm$.012	.488 $\pm$.009	8.525
Stamens, 1903.	4.020 $\pm$.150	2.214 $\pm$.106	55.061
Stamens, 1904.	5.996 $\pm$.007	.273 $\pm$.005	4.557
Stamens, 1907.	3.686 $\pm$.052	2.093 $\pm$.037	56.719

The means and standard deviations, with their probable errors, and the coefficients of variation, are given in Table A for the three characters studied.

Comparing the constants for the three years, we see that the means for sepals and petals agree fairly well, though differing by several times their probable errors. The means of the large stamens, however, are widely different in the

three collections. Perhaps the differences in the standard deviations show somewhat greater irregularities than do the means. Turning to the coefficients of variation for the three characters, we note that while there is considerable fluctuation from series to series, and from year to year, for the sepals and petals, the constants are of the same general order of magnitude. For both sepals and petals they are conspicuously lower in 1904. For the large stamens, the values for 1903 and 1907 are in close agreement, but differ widely from that for 1904.

For comparison with these constants we note that Pearson and his associates* found the coefficient of variation for *Ficaria ranunculoides* to range from 3.24 to 22.02 for the sepals, from 5.34 to 14.60 for the petals, and from 12.12 to 18.77 for the stamens, in various habitats. Calculating the coefficients of variation from Yule's† means and standard deviations for sepals of *Anemone nemorosa* from a series of habitats, I find that they range from 9.8 to 13.4. I have also calculated the coefficients of variation for the lateral flowers of *Adoxa* from the data given by Whitehead‡ and find that the values range from 7.35 to 10.41.

TABLE B. CORRELATION IN LAGERSTROEMIA.

Relationship and Series.	Correlation and Probable Error.
Sepals and Petals in 1903.....	1.000 ± .000
Sepals and Petals in 1904.....	.724 ± .012
Sepals and Petals in 1907.....	.879 ± .006
Sepals and Stamens in 1903.....	.082 ± .067
Sepals and Stamens in 1904.....	.438 ± .020
Sepals and Stamens in 1907.....	— .046 ± .025
Petals and Stamens in 1903.....	.082 ± .067
Petals and Stamens in 1904.....	.591 ± .016
Petals and Stamens in 1907.....	— .032 ± .025

The coefficients of correlation and their probable errors appear in Table B.

* Pearson, K. and others. *Biometrika*. **2**: 148. 1902.

† Yule, G. U. *Biometrika*. **1**: 307–309. 1901.

‡ Whitehead, H. *Biometrika*. **2**: 108–113. 1902.

From these values it appears that the number of sepals and the number of petals are very closely interdependent, all the coefficients falling above .700*. The values obtained by others for *Ficaria ranunculoides* show correlation ranging from .099 to .291 for sepals and petals. The correlations for sepals and stamens, and for petals and stamens agree in having the coefficients for 1903 and 1907 insignificant† while those for 1904 lie in the neighborhood of .500, and are clearly significant with regard to their probable errors. The correlations for *Ficaria* range from .023 to .223 for sepals and stamens, and from .224 to .382 for petals and stamens. I am rather surprised to find such low values representing the interdependence of the number of floral parts.

The foregoing remarks are presented primarily as a contribution of quantitative data on a species which has attracted the attention of a number of well-known botanists, first among whom was Darwin. General conclusions cannot be drawn from them, but the disagreement of the constants from the several series, coupled with the statement of taxonomists concerning the condition of the dimorphic stamens in different species, seems to indicate that there is a promising field for the attention of some one who can take up the investigation on material growing under more normal conditions. Some will say that the disagreements of these constants show that biometric methods are useless in their application to questions such as this. To my mind quite the reverse is true. They show that there are problems which can only be solved by the delicate technique of higher statistics. And, most important of all, perhaps they indicate the limits of trustworthiness of our conclusions.

* The probable error of the first coefficient in the table is given as 0, but while this is the value given by the usual formula, too great biological significance must not be attached to it. A slightly larger collection of material might have given r less than 1, and the probable error would then have been rather high because of the smallness of N .

† I have not considered the form of the regression line in these tables. Possibly the correlation ratio would give a positive relationship between these characters, but I have not felt it worth while to calculate this constant on these series of material. What we need is more data!

TABLE I. 1903. SEPALS AND PETALS.

Petals.					
		5	6	7	Totals.
Sepals	5	16	..	..	16
	6	..	79	..	79
	7	..	..	4	4
	Totals	16	79	4	99

TABLE II. 1903. SEPALS AND STAMENS.
(Petals and stamens show the same correlation.)

Stamens.										
		0	1	2	3	4	5	6	7	Totals.
Sepals	5	..	..	2	2	5	6	1	..	1
	6	13	5	6	9	6	3	37	..	79
	7	..	..	..	..	..	..	1	3	4
	Totals	13	5	8	11	11	9	39	3	99

TABLE III. 1904. SEPALS AND PETALS.

Petals.						
		5	6	7	8	Totals.
Sepals	5	15	39	..	..	54
	6	..	677	4	..	681
	7	..	1	25	..	26
	8	..	..	..	2	2
	Totals	15	717	29	2	763

TABLE IV. 1904. SEPALS AND STAMENS.

Stamens.						
		4	5	6	7	Totals.
Sepals	5	..	10	44	..	54
	6	2	14	660	5	681
	7	..	..	7	19	26
	8	..	..	1	1	2
	Totals	2	24	712	25	763

T. V. 1904. PETALS AND STAMENS.

Stamens.						
		4	5	6	7	Totals.
Petals	5	..	10	5	..	15
	6	2	14	6	9	717
	7	..	..	9	20	29
	8	..	..	1	1	2
Totals		2	24	712	25	763

TABLE VI. 1907. SEPALS AND PETALS.

Petals.						
		4	5	6	7	Totals.
Sepals	4	4	..	..	..	4
	5	6	161	3	..	170
	6	2	23	535	1	561
Totals		12	184	538	1	735

TABLE VII. 1907. SEPALS AND STAMENS.

Stamens.										
		0	1	2	3	4	5	6	7	Totals.
Sepals	4	..	..	1	..	2	1	..	..	4
	5	6	2	16	27	57	58	4	..	170
	6	84	56	57	54	47	62	200	1	561
Totals		90	58	74	81	106	121	204	1	735

TABLE VIII. 1907. PETALS AND STAMENS.

Stamens.										
		0	1	2	3	4	5	6	7	Totals.
Petals	4	1	..	2	1	5	3	..	..	12
	5	8	6	14	28	60	62	6	..	184
	6	81	51	58	52	41	56	198	1	538
	7	..	1	..	..	..	..	..	..	1
Totals		90	58	74	81	106	121	204	1	735